REMARKS

The proposed amendment is responsive to the Office Action dated 27th January 2004. We understand that the deadline for response is **27th July 2004**.

Claim Amendments

Claims 1 and 15 are amended to specify ion beam implantation and to introduce the feature that the ions are incorporated at a level whereby bone ongrowth onto the implant is enhanced as compared with unmodified bioactive material. Support for this amendment may be found on page 3, seven lines from the bottom.

Claim 18 is amended to depend on independent claim 15.

Description of the Present Invention

The provision of bone implants with a coating of a bioactive material such as hydroxyapatite is well known. *In situ*, the coating of bioactive material enables bone ongrowth onto the implant. In the absence of such coating bone does not become physically and chemically bonded to the implant (see Background of present specification).

The present invention is directed to improving the bone ongrowth properties of bone implants. In other words, the invention is concerned with improving the bioactivity of the surface of the implant.

The invention achieves this improvement by incorporating ions from the selected groups of the periodic table set out in claim 1. The ions are incorporated into or onto the surface of the bone implant by ion beam implantation up to a maximum depth of 200 nm. This feature makes it clear that the ions are incorporated only at the surface of the coated implant *i.e.* only at the surface of the bioactive material. This alters the surface chemistry of the surface material to the extent that there is an increase in its bioactivity. The surface structure and mechanical properties are not substantially affected. This is important because the strength and longevity of the implant do not suffer.

In order to achieve the enhanced bioactivity of the surface material the ions are incorporated into the surface at a relatively dilute level. This feature is reflected in a proposed amendment to claim 1 which is attached. Feature (c) of claim 1 now indicates that the ions are incorporated at a level whereby bone ongrowth onto the implant is enhanced as compared with unmodified bioactive material. The inventors believe that the ions (which may form atoms *in situ*) locate in the interstices of the bioactive material coating. Thus, according to the invention, there is no coating of the bioactive surface by the implanted ions. The enhanced bioactivity achieved by the ion implantation of the present invention is therefore achieved by interstitial incorporation of atoms/ions just at the surface of the bioactive coating. The effect of this incorporation is to increase bone ongrowth onto the

bioactive material and to increase mechanical bonding of the bioactive coating to bone. **This is surprising and is not predicted by the prior art.**

Claim Rejections – 35 USC 103

The official action cited the two prior art references of Constantz and Nastasi against the present claims. The main points of the applicant's position are set out below.

Prior Art

Neither Constantz nor Nastasi disclose the present invention. Both of these documents are concerned with the production of hydroxyapatite coatings in several layers. Each layer of hydroxyapatite is bound to the next and the hydroxyapatite coating forms a bond with the underlying metal of the implant. Thus, both Constantz and Nastasi are concerned with treatments of the metal or hydroxyapatite so as to improve the strength of the bond between layers. Neither of these documents is concerned with an enhancement of bioactivity of the hydroxyapatite coating of the coated implant.

Nastasi is concerned with the application to a titanium surface of successive layers of hydroxyapatite to strengthen the adhesion of the hydroxyapatite coatings to the titanium alloy (col 3, lines 2 and 3). Col 5, line 5 indicates that subsequent layers of hydroxyapatite are added to provide a gentle density gradient. This passage indicates that the final layered prosthesis would provide greater strength than those presently available. The total coating thickness is indicated to be between 50 and 200 μm (50,000 to 200,000 nm).

The entire purpose of Nastasi is to alter the mechanical strength of the prosthesis and not to alter the bioactivity of the surface of the hydroxyapatite coating. This is made clear in claim 1 of Nastasi where it is indicated that ions from the ion implantation step are used to densify the hardened hydroxyapatite layer and penetrate the densified hydroxyapatite layer to travel into the titanium alloy prosthesis. It follows that this ion implantation treatment would enable the ions to penetrate the total coating thickness of up to 200,000 nm – three orders of magnitude larger than the 200 nm required by the present invention.

This contrasts completely with the present invention where ion implantation occurs only at the very surface of the hydroxyapatite coating so that the mechanical strength of the implant is not affected. **There is no disclosure or suggestion in Nastasi that the ions should be incorporated only to a maximum depth of 200 nm and there is no disclosure or suggestion that the ions should be incorporated at a level whereby bone ongrowth onto the implant is enhanced.** This is because Nastasi is concerned entirely with the mechanical structure of the implant and not with the bioactivity of the surface of the bioactive hydroxyapatite layer. If it is the intention of Nastasi to improve the bonding between metal and hydroxyapatite coating, this would have absolutely no bearing on the bioactivity of the surface of the hydroxyapatite coating in Nastasi. Indeed, given that Nastasi has as its sole purpose to alter the mechanical strength and structure of titanium alloy prostheses, it could not have been obvious to the skilled reader to have applied an ion beam implantation method to a very narrow surface region of the hydroxyapatite coating when Nastasi expressly teaches

a treatment which penetrates multiple layers of coating. Nastasi therefore teaches away from the present invention suggesting that the invention would not be obvious to the skilled addressee in the light of Nastasi.

Constantz is similarly concerned with multiple layers of hydroxyapatite (col 3, lines 22 *et seq*). Lines 49 to 51 of col 3 indicate that the total thickness of second and succeeding layers would generally be in the range of 5 μm to 20 μm (5,000 nm to 20,000 nm). Constantz does not disclose ion beam implantation and the methods used in Constantz would not achieve the interstitial incorporation of atoms or ions in the first 200 nm at the surface of a bioactive hydroxyapatite coating required by the present invention. Instead, Constantz is concerned only with wet chemistry and does not describe ion beam treatment at all. Col 3, lines 52 *et seq* indicate the various methods by which the chemistry of Constantz is carried out. Constantz actually teaches modification of the hydroxyapatite for the purpose of influencing the *in vivo* dissolution behaviour of the coating itself (col 2, lines 53 to 55). The chemical structure of the hydroxyapatite is actually altered by the use of the ions applied in solution. According to col 2, lines 52 and 53 phosphate and hydroxide anions of the hydroxyapatite and up to 50% of the calcium cations will be substituted with other ions. This represents a potentially significant proportion of the hydroxyapatite whose chemical constitution would be affected in this way. The result of Constantz will be to provide a chemically modified coating potentially to a depth of the hydroxyapatite significantly in excess of the depth specified in the present invention. The purpose of this coating is to affect the resorbability of the coating itself and not to enhance the bioactivity of the surface of the hydroxyapatite coating. We submit that it would not have been obvious to the skilled addressee to have turned to ion beam implantation as a means to achieve the purpose of Constantz. Equally, to address the problem of bioactivity, there is no motivation from Constantz to turn to ion beam implantation. Even if ion beam implantation had been considered, Constantz teaches chemical modification by providing a coating to affect hydroxyapatite resorbability. There is no disclosure or suggestion of increased bone ongrowth onto the coating or increased mechanical bonding of the hydroxyapatite coating to bone. Nothing in Constantz provides a teaching that ions should be incorporated at a sufficient level whereby bone ongrowth onto the implant is enhanced as compared with unmodified bioactive material.